PATENT SPECIFICATION

968,

DRAWINGS ATTACHED.

Inventors: STUART ALEXANDER ANDREWS an RBERT WILLIAM CHARLES SH

968,503

Date of filing Complete Specification : *Dec. 22, 1960.*

Application Date : *Dec. 24, 1959.* *No. 43866/59.*

Complete Specification Published : *Sept. 2, 1964.*

Index at Acceptance :—G1 N(1A2C, 1A3A, 1A4, 1B1, 1C, 1D7, 3S1, 3S7F1, 3S7J, 4A).

International Classification :—G 08 c.

COMPLETE SPECIFICATION.

Torquemeter.

SPECIFICATION NO. 968,503

By a direction given under Section 17 (1) of the Patents Act 1949 this application proceeded in the name of BRISTOL SIDDELEY ENGINES LIMITED, a Bri Company, of Stonebridge House, Colston Avenue, Bristol 1.

THE PATENT OFFICE D 28761/1(5)/R.109 200

cylindrical surface concentric with the shaft, two fixed electromagnetic pick-up devices each located adjacent the cylindrical surface of a different one of the elements a signal channel from each pick-up device arranged to derive from picked-up signals, square waves of substantially constant amplitude but having a frequency and phase the same as those of the picked-up signal, and a comparison device arranged to compare the square waves from the two channels to provide a measure of the torque transmitted by the shaft.

There may be a generator driven from the shaft for generating a signal for permenently magnetising the elements. Such a generator enables the magnetisable surfaces to be magnetised in a manner which takes account of slight deflections of the shaft during rotation.

The generator or other magnetising apparatus may be arranged to magnetise both the elements according to a similar pre-determined pattern. It is then simple to obtain a measure of the torque transmitted by comparing the two signals picked up from the two elements.

It is preferred that the or each magnetisable element is in the form of a strip layer or

which the two signal channels are connecte and across the other two corners of whic the comparison device is connected.

It will be appreciated that the output o the comparison device, which is a measur of the torque transmitted, can be used t control the rotation of the shaft, for exampl its speed or the load on it.

The invention includes a multiple torque meter sensitive to the torsonal twist in tw different portions in a rotating member an comprising two torquemeters each as claime in any of the preceding claims, one of th magnetised elements being common to bot the torquementers.

The invention may be carried into practic in a number of ways but two specific embodi ments are shown. largely diagrammatically by way of example in the accompanyin drawings in which :—

Figure 1 shows one form of the invention and

Figure 2 shows a modification of th arrangement shown in Figure 1.

In the form of the invention shown i Figure 1, the rotatable member comprises shaft 11 which is provided with a torsio meter according to the invention. Tw spaced support members, each in the form o

[*Price*

PATENT SPECIFICATION 968,503

DRAWINGS ATTACHED.

Inventors :—STUART ALE[illegible]DER ANDREWS and HERBERT WIL[illegible]I CHARLES SHEEN.

968,503

Date of filing Complete Specification : Dec. 22, 1960.

Application Date : Dec. 24, 1959. No. 43866/59.

Complete Specification Published : Sept. 2, 1964.

Index at Acceptance :—G1 N(1A2C, 1A3A, 1A4, 1B1, 1C, 1D7, 3S1, 3S7F1, 3S7J, 4A).

International Classification :—G 08 c.

COMPLETE SPECIFICATION.

Torquemeter.

We, THE DE HAVILLAND ENGINE COMPANY LIMITED, a Company registered under the laws of Great Britain, Leavesden, Hertfordshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement :—

This invention relates to torquemeters.

According to the present invention a torquemeter comprises a shaft carrying two axially-spaced elements each with a magnetisable cylindrical surface concentric with the shaft, two fixed electromagnetic pick-up devices each located adjacent the cylindrical surface of a different one of the elements a signal channel from each pick-up device arranged to derive from picked-up signals, square waves of substantially constant amplitude but having a frequency and phase the same as those of the picked-up signal, and a comparison device arranged to compare the square waves from the two channels to provide a measure of the torque transmitted by the shaft.

There may be a generator driven from the shaft for generating a signal for permenently magnetising the elements. Such a generator enables the magnetisable surfaces to be magnetised in a manner which takes account of slight deflections of the shaft during rotation.

The generator or other magnetising apparatus may be arranged to magnetise both the elements according to a similar pre-determined pattern. It is then simple to obtain a measure of the torque transmitted by comparing the two signals picked up from the two elements.

It is preferred that the or each magnetisable element is in the form of a strip layer or wire of a magnetisable material or possibly is in the form of a sprayed on layer on the shaft or on a support carried by the shaft.

However, a part of the shaft may be of magnetisable material, and then each element may be magnetically insulated from that part of the shaft.

A feature of the invention is the comparison device by means of which the two picked up signals are compared. In one form of the invention this comprises a bridge network of impedances to opposite corners of which the two signal channels are connected and across the other two corners of which the comparison device is connected.

It will be appreciated that the output of the comparison device, which is a measure of the torque transmitted, can be used to control the rotation of the shaft, for example its speed or the load on it.

The invention includes a multiple torquemeter sensitive to the torsonal twist in two different portions in a rotating member and comprising two torquemeters each as claimed in any of the preceding claims, one of the magnetised elements being common to both the torquementers.

The invention may be carried into practice in a number of ways but two specific embodiments are shown, largely diagrammatically, by way of example in the accompanying drawings in which :—

Figure 1 shows one form of the invention ; and

Figure 2 shows a modification of the arrangement shown in Figure 1.

In the form of the invention shown in Figure 1, the rotatable member comprises a shaft 11 which is provided with a torsion meter according to the invention. Two spaced support members, each in the form of

an annular aluminium drum 12 and 13, are mounted co-axially upon the shaft 11.

The drums 12 and 13 may be integral with the shaft or may be secured to the shaft in any convenient manner, for example by means of splines or dowel pins, and in such a way that they constitute part of the rotatable member and rotate therewith.

The curved peripheral surface of each drum 12 or 13 carries an annular magnetisable member 14, in the form of a strip, a layer, or a wire, of magnetisable material. The material in question may be a ferro-magnetic metal, a suitably impregnated plastic strip, a sintered magnetic oxide material, or any other suitable magnetisable material.

Two similar sensitive heads 15, 16 each comprising a combined electromagnetic pick-up device and electromagnetic magnetising and erasing head and being in the form of a single coil unit having a pair of terminals, are fixed adjacent the curved surfaces of the respective drums to co-operate with the respective magnetisable elements.

The electrical connections to the terminals of the sensitive heads 15, 16 are controlled by a seven-contact electric switch 17, each contact being of the on-off type, and four of the contacts being normally closed while three of the contacts are normally open.

Thus what may be termed the negative terminal of one of the sensitive heads 15 is connected through one of the normally closed contacts 18 of the electric switch 17 to earth, while the positive terminal of the other sensitive head 16 is similarly connected to earth through another normally closed contact 19 of the electric switch. The positive terminal of the sensitive head 15 is connected, through another normally closed contact 21 of the electric switch, to the input of a gain-stable amplifier 22 the output of which is connected to the input of an amplitude limiter 23.

The output of the amplitude limiter 23 is connected to the input of a ring-of-three gain-stable amplifying unit 24 comprising an amplifier the last stage of which is a cathode-follower circuit, and a negative-feedback circuit inter-connecting the input and the output of the amplifying unit.

The output of the amplifying unit 24 is connected on the one hand through a resistor 25 to earth, and on the other hand through a second resistor 26 to a common point which is connected to one terminal of an alternating-current electrical meter 27 the other terminal of which is connected to earth, the terminals of the electrical meter being shunted by a further resistor 28.

The negative terminal of the other sensitive head 16 is connected, through another normally closed contact 29 of the electric switch 17, to a circuit containing similar elements 22, 23, 24, 25, 26 to those associated with the first head.

The positive terminal of the first sensitive head 15 is also connected, through a normally open conta[illegible] of the electric switch, to one of the two output terminals of a generator 32 coupled to the shaft 11 the other output terminal of which is connected, through another normally open contact 33 of the electric switch, to the negative terminal of the other sensitive head 16. Further, the negative terminal of the first sensitive head 15 is connected to the positive terminal of the other sensitive head 16, through the third normally open contact 34 of the electrical switch 17.

The generator 32 may be arranged to provide suitable electrical signals of any suitable shape or wave form, but preferably the electrical signals are sinusoidal oscillations.

The operation of the device is as follows. After the drums 12 and 13 have been mounted upon the shaft 11, and after the magnetisable elements 14 have been secured to the drums, the electric switch 17 is operated and each of the magnetisable elements is magnetised by means of the sensitive heads 15 and 16 (acting as magnetising heads) and by use of the generator 32. Care is taken to ensure that each of the magnetisable elements is similarly magnetised (in the present example the sensitive heads are connected in series for this purpose, but they may alternatively be connected in parallel), the coupling of the generator 32 to the rotatable member 11 ensuring that the magnetisation of each magnetisable element varies in the same way as does the electrical output of the generator, irrespective of the manner in which the angular position of the shaft is varied during magnetisation.

The intensity of the magnetisation of each of the magnetisable elements 14 will vary periodically and sinusoidally around the periphery of the drum concerned, that is to say the intensity of magnetisation will vary lengthwise of each of the magnetisable elements from zero to a maximum value in one sense, and will then return to zero, reach a maximum value in the opposite sense, and will then again return to zero, and so on as indicated diagrammatically by the line 36. The two "senses" of magnetisation just referred to are distinguished by the fact that in one case the magnetisation may be regarded as an alignment, peripherally of the drum, of elementary magnets having their North-South axes pointing in the direction of rotation of the drum, while in the other case the elementary magnets have the reverse orientation.

When the magnetisable elements have been so magnetised, and when the electric switch 17 has been returned to its normal position shown in Figure 1, a corresponding sinusoidal electrical output signal will be

induced in each pick-up head 15 or 16 when the shaft 11 rotates.

It will be seen that the circuit arrangement is such that the output signals are fed, with relatively opposite polarities, each into an individual amplifying and wave-shaping circuit where it is first amplified by means of the gain-stable amplifier 22, and then converted by means of the amplitude limiter 23 into a square wave which is then amplified in turn by means of the gain-stable amplifying unit 24.

The two resulting signals are then combined at the common point, and it will be seen that the arrangement is such that the resultant current flowing from the common point to earth through the current meter 27 is the algebraic sum of these two signals, the resistance 28 shunting the current meter acting as an overall sensitivity adjustment, and the four resistors 25, 26 connected in bridge formation between the output of the gain-stable amplifying units 24 and, on the one hand, earth, and on the other hand, the common point, acting as individual sensitivity adjustments for the two sensitive heads 15, 16.

The design of each amplitude limiter 23 is such that variations of the angular velocity of roation of the shaft 11 will not appreciably affect the amplitude of the output signal from each amplitude limiter. Thus, the indicated current of the current meter 27 will be independent of the velocity of rotation of the shaft except insofar as the frequency of that current will vary with the angular velocity of rotation of the shaft.

It is intended that the magnetisable elements shall be magnetised when the shaft is rotating under no-load conditions, that is to say when the torsional twist in that portion of the shaft 11 extending between the two drums 12, 13 is zero, or at least effectively zero. Thus, when the shaft is rotated after the magnetisable elements 14 have been magnetised, and under no-load conditions, the current meter 27 should read zero; if not, the bridge-formation resistors 25, 26 should be suitably adjusted to bring this about.

When, thereafter, the shaft 11 is rotating under a load, so that there is a torsional twist in the part of the shaft extending between the two drums 12 and 13, a relative angular displacement of the two drums will occur. It will be seen that this will cause a change in the phase relationship existing between the magnetic signals on the two magnetised elements 14, and therefore a corresponding change in the phase relationship between the electrical output signals of the pick-up devices 15, 16. A resultant electrical current will therefore flow through the current meter 27, and magnitude of this current will be a measure of the magnitude of the torsional twist in that part of the shaft extending between the two drums.

It will, of course, be appreciated that, if required, the magnetisable elements can be magnetised while the shaft is loaded; the reading of the current meter will in this case be determined by the difference between the torsional twist in the portion of the shaft extending between the two drums at the moment of measurement, and under the conditions of magnetisation.

Where the generator is a source of sinusoidal oscillations, the frequency of these oscillations should be so chosen that the indicated current of the current meter 27 is a maximum when the maximum desired load is applied to the shaft. It will be appreciated that the current will be a maximum when the electrical output signals from the pick-up devices 15, 16 are 180° out of phase, and that the frequency must therefore be so chosen that the maximum desired load corresponds to a 180° phase difference of these electrical output signals. Thus the more minute the values of torsional twist that are required to be detected in the rotating shaft, the higher should be the frequency employed. The electrical apparatus should preferably be designed to give optimum performance at the frequency concerned.

Where the generator 32 is arranged to generate wave-forms or shapes other than sinusoidal oscillations, for example wave-forms of the kind known as square waves or square-peaked waves, the electrical apparatus should be designed to operate successfully with such wave forms.

As an alternative to the current meter 27, an oscilloscope can be used to display the resultant of the electrical output signals from the pick-up devices.

It will be appreciated that whereas the resultant of the electrical output signals from the pick-up devices 15, 16 is determined by the magnitude of the torsional twist in the part of the shaft extending between the two drums, and that therefore that resultant is fundamentally an indication of that torsional twist, the apparatus may be so calibrated that the resultant is a measure of some other factor which is associated with that torsional twist, for example the torsional couple applied to the shaft, the acceleration of the shaft, the horse-power transmitted by the shaft, and so on.

Alternatively, or in addition, the resultant of the electrical output signals may be arranged to act as an input signal to a control system shown diagrammatically as 39 arranged to control the speed of rotation of the rotatable member, or to control some other quantity associated with that rotation and which is required to be controlled automatically in accordance with the magnitude of the torsional twist in the shaft.

If the range of the torsional twist in the part of the shaft extending between the two drums, to which the torsion meter is to be sensitive, is required to be altered, then each of the magnetisable elements can be demagnetised using the erase head and then suitably re-magnetised in a different manner.

It is not essential that each magnetisable element 14 be in the form of a closed loop, although this is convenient; an incomplete loop may be used.

In modifications of the specific embodiment which has been described, the magnetisable elements 14 may be secured to the shaft 11 in any convenient manner. Thus, for example, provided that the axial float of the rotating shaft is not excessive, the magnetisable elements could be in the form of annular discs 41 (dotted in Figure 1) secured to the sides of the drums 12 and 13. The magnetisable elements 14 could be secured directly to the outer surface of the shaft or, where the shaft is tubular, to the inner surface of the shaft. The shaft may be formed with integral bushes or the like designed to carry the magnetisable elements.

In some cases the length of the shaft 11 extending between the drums 12 and 13 may be inconveniently large. In such cases, one of the drums may be indirectly mounted upon the shaft 11 by means of an extension piece, in such a way that the drums are brought into suitably close proximity. Thus, in a modification of the invention shown in Figure 2 the arrangement is generally similar to that of the specific embodiment described, but one of the drums 13 has a central clearance hole 43 through which the shaft 11 extends, and is secured indirectly to the shaft by way of a sleeve 44 extending co-axially with the shaft to a collar 45 mounted upon the shaft at the required effective position of the drum concerned. The sleeve 44 must be constructed to transmit faithfully angular movements of the collar to the drum 13.

WHAT WE CLAIM IS :—

1. A torquemeter comprising a shaft carrying two axially-spaced elements each with a magnetisable cylindrical surface concentric with the shaft, two fixed electromagnetic pick-up devices each located adjacent the cylindrical surface of a different one of the elements, a signal channel from each pick-up device arranged to derive from picked-up signals, square waves of substantially constant amplitude but having a frequency and phase the same as those of the picked-up signal, and a comparison device arranged to compare the square waves from the two channels to provide a measure of the torque transmitted by the shaft.

2. A meter as claimed in Claim 1 including magnetising apparatus capable of permanently magnetising the elements on the shaft.

3. A torquementer as claimed in Claim 2 including a generator for generating a signal for permanently magnetising the elements, which generator is driven from the shaft.

4. A meter as claimed in Claim 2 or Claim 3 in which the magnetising apparatus is arranged to magnetise both the elements according to a similar pre-determined pattern.

5. A meter as claimed in any of the preceding claims in which each pick-up device is part of a combined electro-magnetic magnetising and pick-up device constituting a single unit.

6. A meter as claimed in Claim 5 in which the single unit also incorporates de-magnetising apparatus.

7. A meter as claimed in any of the preceding claims in which the or each magnetisable element is in the form of a strip, layer, or wire of a magnetisable material.

8. A meter as claimed in any of the preceding claims in which each magnetisable element is secured to the shaft.

9. A meter as claimed in Claim 8 in which a part of the shaft is of a magnetisable material, and in which each magnetisable element is magnetically insulated from that part of the shaft.

10. A meter as claimed in any preceding claim in which the magnetisable element is in the form of a sprayed-on layer on the shaft or on a support carried by the shaft.

11. A meter as claimed in any of the preceding claims in which each element is magnetised in a sinusoidal pattern.

12. A torquementer as claimed in any preceding claim in which the comparison device comprises a bridge network of impedances to opposite corners of which the two signal channels are connected and across the other two corners of which the comparison device is connected.

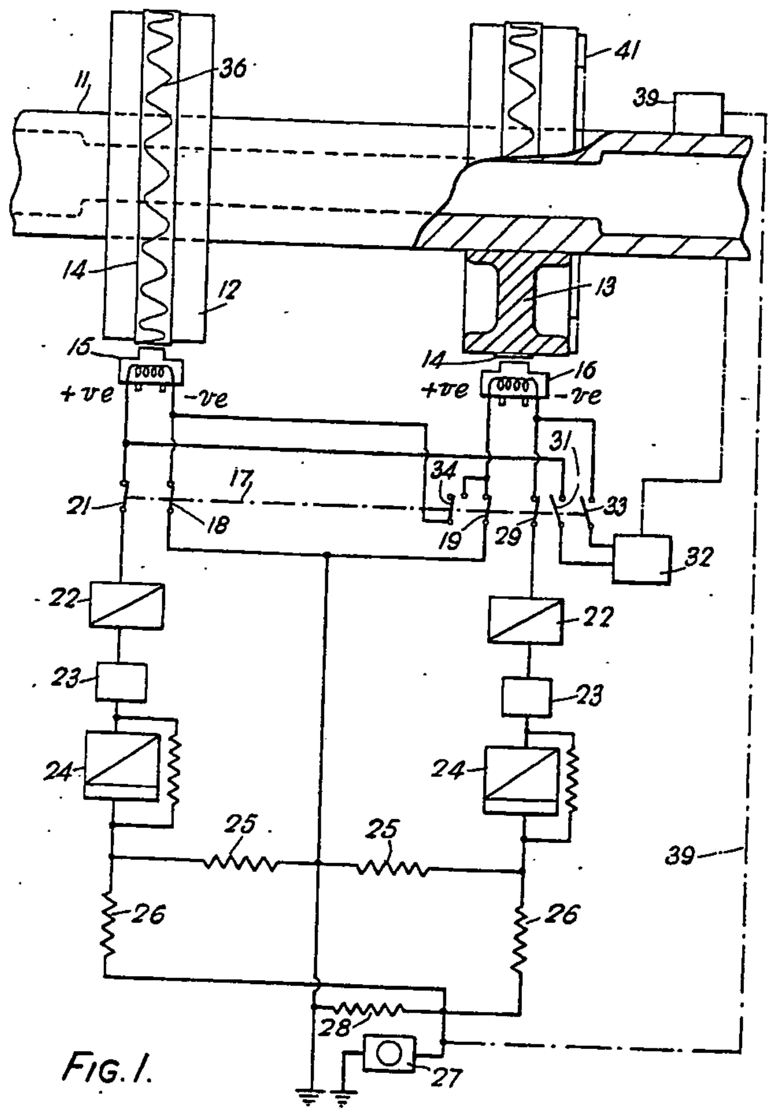
13. A meter as claimed in any of the preceding claims including means for controlling the roation of the shaft member in dependence upon the output of the comparison device.

14. A multiple torquementer sensitive to the torsional twist in two different portions in a rotating member, and comprising two torquemeters each as claimed in any of the preceding claims and in which one of the magnetised elements is common to both the torquementers.

15. A torquemeter constructed and arranged substantially as described herein with reference to Figure 1 or to Figure 2 of the accompanying drawings.

KILBURN & STRODE,
Chartered Patent Agents,
Agents for the Applicants.

Abingdon : Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1964
Published at The Patent Office, 25 Southampton Buildings, London, W.C.2,
from which copies may be obtained.



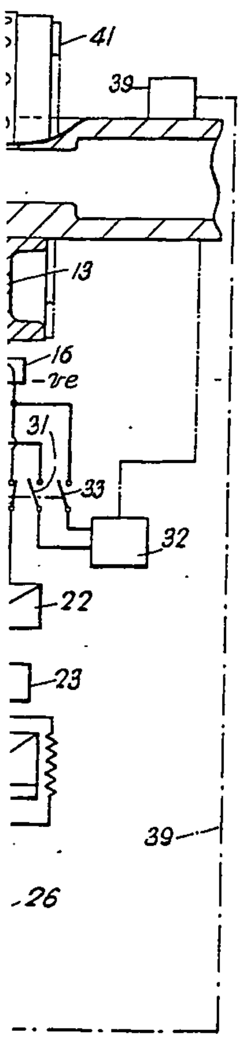
11
36
41
39
14
12
13
15
16
+ve
-ve
17
21
18
34
19
29
31
33
32
22
23
24
25
26
28
27

FIG. 1.

968503 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2



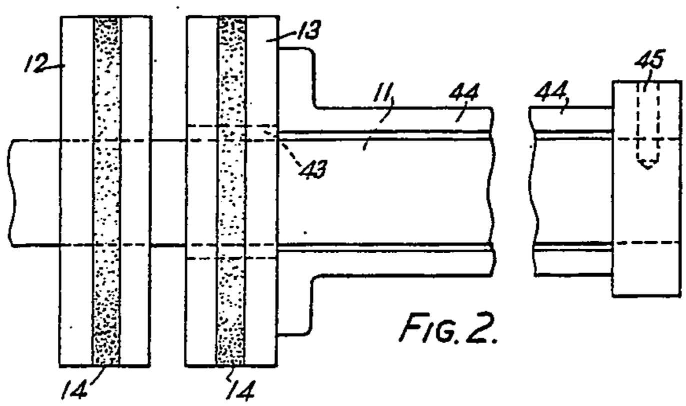
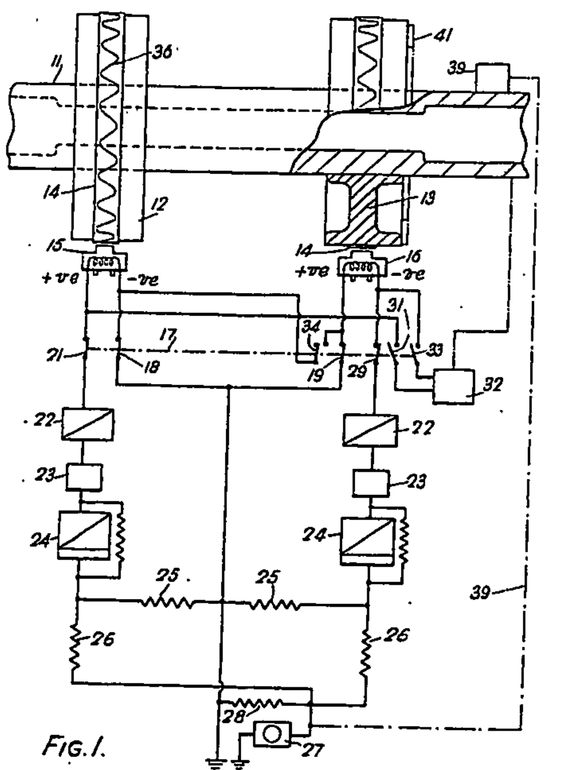
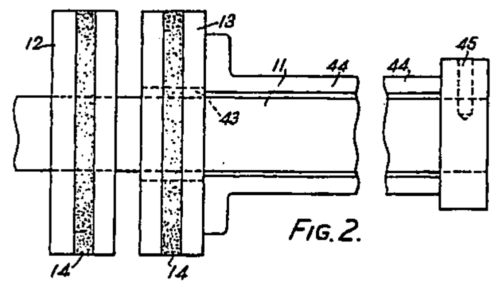


FIG. 2.


11
36
41
39
14
12
13
15
14
16
+ve
-ve
+ve
-ve
31
34
17
33
21
18
19
29
32
22
22
23
23
24
24
25
25
39
26
26
28
27
FIG. 1.


12
13
45
11
44
44
43
14
14
FIG. 2.